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THE LUMBAR CURVE OF THE SPINAL COLUMN IN  
SEVERAL RACES OF MEN. By Professor Sir WILLIAM  
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IN the course of the investigations into the modifications of the skeleton in different races of men, which I have been conducting in connection with my Report on the Human Skeleton for the Reports of H.M.S. "Challenger," I have measured the bodies of the lumbar vertebræ, with the view of ascertaining if modifications existed in their vertical diameter, anteriorly and posteriorly, which might affect the lumbar curve of the spine. If the vertical diameter of the series of lumbar bodies be less anteriorly than posteriorly, then the lumbar region possesses (if this be not compensated for by modifications in the thickness of the intervertebral discs) an anterior concavity, continuous with the anterior concavity in the dorsal region; and an approximation to the curvature of the spine is produced, such as is characteristic of the spinal column in all mammals except man.

Anatomists are in the habit of teaching that the human spine is convex forward in the lumbar region, so that a lumbar convexity is interposed between the thoracic and sacral concavities, and contributes to the alternating series of concavo-convex curves of the spinal column, which are associated with the erect attitude of man. My belief in the universality of the view that the human spine is invariably convex forward in the lumbar region was disturbed some years ago, when Charles Robertson, Esq., of the Oxford Museum, showed me the skeleton of an aboriginal Australian in that museum, which he had articulated in 1873. Mr Robertson told me that the skeleton was that of an adult male of the Tomki tribe of the Richmond River, N.S.W. In it there was a continuous curve, concave forwards through both thoracic and lumbar regions. As the skeleton was, however, artificially articulated, the question naturally arose in one's mind if this modification in the lumbar curve might not have been produced by some peculiarity in the method of articulation, and was not therefore natural to the spine. Since I saw this skeleton, however, Mr Robertson has written to tell me of another adult male from Port Augusta, South Australia,

articulated in 1878, which exhibited a similar concavity in the lumbar region, and that the articulated skeletons of a Gilbert Islander and a male Andaman Islander have a similar lumbar concavity, though not so well marked. Before I had heard, however, of these later specimens in the Oxford Museum, I had examined the lumbar vertebræ in the series of spines at my disposal, and had obtained some interesting results.

Two important factors contribute to the curve in the lumbar region, viz., the vertebral bodies and the intervertebral discs. The exact share contributed by each of these parts can only be ascertained with precision by the method of observation which Professor D. J. Cunningham, of Trinity College, Dublin, is conducting, of making longitudinal mesial sections through the long axis of the spine in frozen subjects, and then carefully measuring the relative thickness both of the vertebral bodies and the discs. In the absence, however, of the fresh bodies of Australians and other aborigines, I have been precluded from obtaining any information on the thickness of the discs, and have been restricted to the examination of the vertebræ themselves, so far as they have been preserved in the skeletons which have reached me. I have measured, therefore, the vertical diameter of the body of each lumbar vertebra, both in front and behind, and have noted the difference in each vertebra, and in the series of lumbar vertebræ in each spine.

In order to obtain some data for comparison I measured the lumbar vertebræ in twelve adult European spines, the majority of which were males, and found that the vertical diameter of the anterior surface of the bodies of the five vertebræ in each spine was collectively greater than the vertical diameter of the posterior surfaces in the same spine. The maximum difference between the collective depth of these surfaces in the series of five vertebræ was 11 mm. in one skeleton, and the minimum difference was 1 mm. in another skeleton. The mean collective depth of the five vertebræ in the twelve European skeletons was 137 mm. for the anterior, and 131·4 for the posterior surface, the mean difference therefore was 5·6 mm. in favour of the anterior surface. If we were to assume that in these spines each intervertebral disc was of equal thickness throughout, then the greater thickness of the vertical diameter of the bodies in front than behind in each spine would give a slight convexity forwards to the spinal column in the lumbar region. But there is reason to believe that this difference in vertical diameter is not limited to the vertebral bodies, and that some of the discs also are thicker anteriorly than posteriorly so as to increase the anterior convexity.

If we now examine the individual lumbar vertebræ in each of these European spines we shall find that with only two exceptions the body of the 1st lumbar vertebra was deeper behind than in front, in one instance 6 mm., in another 4 mm. but usually not more than 1 or 2 mm.; in the exceptional cases the anterior and posterior vertical diameters were equal. The body of the 2nd lumbar was deeper behind than in front in six spines; they were equal in depth in four spines, and the anterior surface was deeper than the posterior in two spines. The body of the 3rd lumbar was deeper in front than behind in ten spines, and in two they were equal. The body of the 4th lumbar was deeper in front than behind in eleven spines, and deeper behind than in front in one specimen. The body of the 5th lumbar was deeper in front than behind in all the specimens. From these spines it is evident that, whilst in the 1st and 2nd lumbar vertebræ the body was deeper behind than in front in a considerable proportion of the specimens, in the 3rd and 4th lumbar the reverse occurred, until in the 5th lumbar the bodies of all the specimens had a greater vertical diameter anteriorly than posteriorly, and this indeed is a character of the 5th lumbar that has long been recognised by the descriptive human anatomist. In this series of twelve European spines, if we take the vertical diameter of the body of the 4th lumbar in the series we find that it amounts to 336 mm. for the anterior surfaces collectively, and to 313 mm. for the posterior surfaces collectively. In the 5th lumbar the vertical diameter of the anterior surfaces collectively amounted to 337 mm. and the posterior surfaces to 281 mm.; the mean anterior depth was 28 mm., the mean posterior 23·4, and the mean difference in favour of the anterior surface was 4·6 mm. Hence it follows that of all the lumbar vertebræ the 5th has much the greatest proportional depth at the front than at the back of its body, and that it contributes more than any of the others to the anterior convexity of the lumbar portion of the spinal column.

For the purposes of comparison of the lumbar region in Europeans with that in the spines of other races of men, it may be well to frame a lumbar index both for the entire region and for the body of the 5th lumbar. If we assume the vertical diameter of the bodies of the five vertebræ anteriorly to = 100, then the formula  $\frac{\text{posterior diameter} \times 100}{\text{anterior diameter}}$  would give the index required. If this be applied to the lumbar region in Europeans the mean index in them of the series of five vertebræ is 95, and the mean index of the 5th lumbar vertebra itself is 83.

During the past few years I have collected the skeletons of seven adult aboriginal Australians,—six men and one woman. In four of the men the lumbar spine is complete, in one the last lumbar vertebra has been lost, in another the 3rd, 4th, and 5th lumbar are absent; in the woman all the lumbar are present. In each of the five skeletons in



which the lumbar spine was complete, the vertical diameter of the bodies of the five vertebræ collectively was deeper behind than in front; the maximum difference observed in three male skeletons was 9 mm., the minimum in the woman was 2 mm. The mean collective depth of the five vertebræ in the five perfect Australian skeletons was 112·2 mm. for the anterior surface of the bodies, and 118·8 mm. for the posterior surface; the mean difference, therefore, was 6·6 mm. in favour of the posterior surface. In the relation of the vertical diameter of the posterior surface to the anterior surface the opposite condition prevailed to that which was found in the Europeans. In the skeleton in which the 5th lumbar was absent the collective diameter of the four lumbar was 3 mm. greater behind than in front. Before, indeed, I had measured the vertebræ in these Australians, I found that, when the lumbar in each spine were articulated together, the bodies gave a concave curve forward, and not a convex curve as in the European spine, so that I was not surprised to see, when the bodies were measured, that collectively they were deeper posteriorly than anteriorly.

When the measurements of the individual lumbar vertebræ in the series of Australian spines were examined, it was seen that the body of the 1st lumbar vertebra in every instance was deeper behind than in front, in four skeletons as much as 4 mm. The body of the 2nd lumbar was with one exception deeper behind than in front, in two specimens as much as 4 mm.; in the exceptional vertebra the depth in front was 1 mm. greater than behind. The body of the 3rd lumbar in four skeletons was deeper behind than in front; in one skeleton they were equal, and in another—the adult female—the anterior diameter was 1 mm. deeper than the posterior. The body of the 4th lumbar was deeper behind than in front in three skeletons; these diameters were equal in one, and in two the anterior diameter was greater than the posterior. The body of the 5th lumbar was deeper in front than behind in all the five complete skeletons, the maximum difference between the two surfaces being 3 mm.

When these dimensions are compared with those obtained from the European spines, it will be seen that in the 1st, 2nd, and 3rd lumbar the body was more constantly deeper behind than in front in the Australians than in the Europeans. In the 4th lumbar, whilst it was the exception in the Europeans for the body to be deeper behind than in front, in the Australians one-half the skeletons exhibited this relation. In all the Australians, as in the Europeans, the body of the 5th lumbar was deeper in front than behind; the mean vertical diameter of the anterior surfaces was 23·2, and of the posterior 21·2, a difference of 2 mm. only in favour of the anterior surface; whilst in the Europeans the anterior surface was on the average 4·6 mm. thicker than the posterior.

The mean lumbar index in the Australians was 105·8, and the mean index of the 5th lumbar vertebra was 91.

In my single male Bush skeleton the collective vertical diameter of the bodies of the five lumbar vertebræ was 108 mm. anteriorly, and 115 mm. posteriorly. In the 1st, 2nd, and 3rd lumbar the posterior diameter exceeded the anterior; in the 4th these two diameters were equal, and in the 5th the anterior diameter was 1 mm. greater than

the posterior. The proportions in this skeleton closely corresponded to what was seen in the Australians. The lumbar index was 106, and the index of the 5th lumbar vertebra was 95.

In my series of Andamanese skeletons only two had the lumbar vertebræ complete. In one the vertical diameter of the five vertebræ collectively was 113 mm. anteriorly, and 112 mm. posteriorly; in the other 125 mm. anteriorly, 124 mm. posteriorly. The 1st and 2nd lumbar in both skeletons were thicker behind than in front. The 3rd lumbar in one skeleton was of equal diameter on both aspects, and in the other was 1 mm. thicker behind than in front. In both skeletons both the 4th and 5th lumbar were thicker in front than behind, in the one skeleton the anterior surface of the 5th lumbar being 3 mm., in the other 5 mm., thicker than the posterior. The mean lumbar index of the two skeletons was 99, and the mean index of the 5th lumbar vertebra was 84.

In three Negro skeletons I was able to measure the vertical diameter of the bodies of the lumbar vertebræ both in front and behind. In each of the three skeletons the collective vertical diameter of the five lumbar bodies was slightly greater in front than behind; the maximum difference, however, was only 2 mm. The mean collective depth of the five vertebræ in the three Negro skeletons was 121 mm. for the anterior surfaces, and 119·6 mm. for the posterior surfaces; the mean difference, therefore, was 1·4 mm. in favour of the anterior surface. In all three skeletons, both the 1st and 2nd lumbar were slightly deeper behind than in front; the 3rd lumbar was equal in depth both anteriorly and posteriorly, whilst both the 4th and 5th lumbar were somewhat deeper in front than behind. The mean lumbar index was 98·9, and the mean index of the 5th lumbar vertebra was 89.

In a Maori skeleton, from Otago, the vertical diameter of the series of five vertebræ, was the same both in front and behind, viz., 101 mm. The 1st and 2nd lumbar were slightly deeper behind than in front, the 3rd and 4th were equal in depth on both surfaces, and the 5th was 3 mm. deeper in front than behind. The lumbar index was 100, and the index of the 5th lumbar vertebra was 85.

In each of two female skeletons from Oahu, in the Sandwich Islands, the collective vertical diameter of the five lumbar bodies was greater behind than in front; in the one skeleton the difference was 7 mm., in the other 4 mm., in favour of the posterior surface. The mean collective depth of the five vertebræ in the two skeletons was 117·5 mm. for the anterior and 123 mm. for the posterior surfaces; the mean difference, therefore, was 5·5 mm. in favour of the posterior surface. In both skeletons the bodies of the 1st, 2nd, 3rd, and 4th lumbar were all deeper behind than in front, whilst the 5th lumbar was deeper in front than behind. The mean lumbar index was 104·7, and the mean index of the 5th lumbar vertebra was 87.

In one of three Hindoo skeletons, a tall male,<sup>1</sup> the vertical diameter of the series of five lumbar bodies was 137 mm. anteriorly, and 146 mm. posteriorly. The 1st, 2nd, and 5th lumbar were deeper behind

<sup>1</sup> This skeleton, presented by Dr John Anderson, F.R.S., was estimated as belonging to a man 6 feet high.



than in front, the 3rd was 1 mm. deeper in front than behind, and in the 4th these two diameters were equal. The lumbar index was 106, and the index of the 5th lumbar vertebra 107. In the two other Hindoo skeletons, a male and a female, the vertical diameter of the bodies of the five lumbar was somewhat deeper in front than behind, and the mean lumbar index was 97·8. In each of these skeletons the vertical diameter of the 5th lumbar vertebra was deeper in front than behind, and the mean index was 89. In the skeleton of a male Sikh, the vertical diameter of the five lumbar bodies was 130 mm. anteriorly and 133 mm. posteriorly, being a difference of 3 mm. in favour of the posterior diameter. In this skeleton the 1st and 5th lumbar bodies were deeper behind than in front, but the 2nd, 3rd, and 4th were each of equal diameter on both aspects. The lumbar index was 102, and the index of the 5th lumbar vertebra was 108·7.

In a Chinese skeleton the vertical diameter of the five lumbar bodies was 145 mm. anteriorly, and 123 mm. posteriorly. In each vertebra, except the 1st, the vertical diameter was deeper in front than behind, and in the 1st the two diameters were equal. The lumbar index was 84·8, and the index of the 5th lumbar vertebra was 70. In a male Malay skeleton, the vertical diameter of the five lumbar bodies was 127 mm. anteriorly, and 125 mm. posteriorly. In the 1st, 2nd, and 3rd, the posterior diameter was deeper than the anterior; in the 4th and 5th the anterior diameter was deeper than the posterior. The lumbar index was 98, and the index of the 5th lumbar vertebra was 77·7.

In a female Esquimaux, the vertical diameter of the series of five lumbar bodies was the same in front and behind (127 mm.), so that the lumbar index was 100. In a male skeleton the vertical diameter of the bodies anteriorly was 120 mm., and posteriorly 116 mm., and the lumbar index was 96·6. Both in the female and male the 1st and 2nd lumbar were deeper behind than in front, but the 4th and 5th lumbar were deeper in front than behind. The index of the 5th lumbar vertebra in the female was 81, and in the male 71. In a male Laplander the vertical diameter of the five lumbar vertebræ was 111 anteriorly and 110 posteriorly, and the lumbar index was 99. In a female Laplander the vertical diameter was anteriorly 121 mm., and posteriorly 118 mm. and the lumbar index was 97·5. In both skeletons, whilst the 1st lumbar vertebra was deeper behind than in front, both the 4th and 5th lumbar were deeper in front than behind. The index of the 5th lumbar in the male was 86, and in the female 88.

From the data which are recorded in the preceding pages of the measurements of the lumbar region in thirty-six spines of various races of men, it will be seen that differences occur, often to a considerable degree, in the vertical diameter anteriorly and posteriorly of the bodies of the series of five vertebræ. These differences are expressed numerically by the lumbar index, computed in the manner already explained. The lowest index (84·8) was in a

Chinese skeleton, and the highest (106) in a Bushman and in a male Hindoo, with a mean of 105·8 in a series of five Australians, whilst the mean index of twelve Europeans was 95. The number of Europeans measured may, I think, be regarded as sufficient on which to frame an average. But it would not be safe to speak so definitely of the mean index in the other races, on account of the few skeletons which have as yet been measured. Still, from the fact that each of the five Australian skeletons presented the character of having the vertical diameter of the series of lumbar bodies deeper posteriorly than anteriorly, and from the peculiarities of the two Australian skeletons in the Oxford Museum articulated by Mr Charles Robertson, there can, I think, be little doubt that in that race it is the rule for the lumbar vertebræ to have an opposite relation, as regards the depth of the body, to what is found in Europeans.

So far then as one can judge of the configuration of the lumbar spine by the measurements of the bodies of the vertebræ without the intervertebral discs, this region may present one or other of three forms in different races of men. It may be convex forwards; or straight; or concave forwards, and to each group a numerical limit may be assigned, based on the lumbar index. We may assume that a spine with the lumbar index from 98 to 102, both inclusive, is a straight spine, *Ortho-rachic*; one with an index above 102 is a spine concave forwards, *Koilo-rachic*; and one with an index below 98 is a spine convex forwards *Kurto-rachic*. From the data before me the skeletons which I have measured would be arranged as follows:—The Chinese and Europeans would have convex lumbar regions, the Andamanese, Negros, Maoris, Sikhs, and perhaps Hindoos, Esquimaux, and Lapps would have straight lumbar regions, whilst the Australians, Bush, and Sandwich Islanders would have concave lumbar regions. But this arrangement is of course entirely provisional and will doubtless require to be modified as observations on the lumbar vertebræ are multiplied. Variations in the anterior curvature of the spine in the lumbar region would in all probability affect the outline of the back of the body in the lumbar region, as one would not expect the back to have so well marked a hollow in that region, when the spine is concave forwards as when it possesses the anterior convexity. How far these depart-

ures in the lower races of men from the well-recognised lumbar convexity of the higher races may serve to modify the spine in the erect attitude can only be definitely settled when the intervertebral discs, as well as the vertebral bodies, have been measured.

As regards the 5th lumbar vertebra, in all the races the vertical diameter of the anterior surface of the body is deeper than that of the posterior. There are without doubt differences in the relative depth. The anterior diameter is proportionally greater than the posterior in the Chinese, Malay, Esquimaux, Lapps, Europeans, and Andamanese, than in the Australians, Bush, Negros, and Hindoos. In one Hindoo skeleton, and in the Sikh, the posterior diameter of this vertebra was deeper than the anterior, but these were probably individual exceptions, and this greater depth would assist in giving the high lumbar index exhibited by these two skeletons.

